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A REVIEW OF OIL AND GAS IN VIRGINIA

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Introduction

The year 1959 marks the Centennial of the oil and gas industry in the United States. The first oil well in America was drilled in 1859 at Titusville, Pennsylvania, by the famous Colonel Drake. Oil was struck at a depth of 69 feet after weeks of effort. This first well was capable of producing about 25 barrels of oil per day. In the century that has elapsed since that time the American petroleum industry has grown to be a giant which is called upon to produce over 7,000,000 barrels of oil and billions of cubic feet of natural gas daily. This enterprise has grown so large that each year some 50,000 new wells are drilled in this country and the total number of oil wells now exceeds one-half million.

Virginia has not been as favorably endowed with bountiful supplies of oil and gas as have some of the famous producing states such as Texas and Oklahoma. Large areas of the state are underlain by rock types which are not favorable for the origin and accumulation of oil or gas. Other large areas have been so deformed and eroded that any oil once present has long since escaped or has been destroyed. Nevertheless, exploration for oil and gas deposits has been carried on in Virginia since the 1890's. As a result of these efforts, oil has been found in Lee County, and natural gas has been found in Buchanan, Dickenson, Russell, Wise, Scott, Washington, and Rockingham counties. At the present time, as in the past, activity is mostly confined to the southwestern part of the state. It may be of interest to many people to know that 330 wells have been drilled in search of oil or gas within the borders of Virginia.

Although petroleum products are vital elements of our daily lives, there are many common misconceptions concerning the occurrence of oil and natural gas. These substances do not occur haphazardly throughout the crust of the earth as is often supposed. They occur instead according to definite natural processes with respect to the specific geologic nature and geologic history of a particular area.

Origin and Accumulation

The origin and accumulation of significant amounts of petroleum or natural gas is normally confined to areas underlain by sedimentary rocks. The extent of sedimentary rocks and the distribution of oil and gas fields in Virginia are shown in Figure 1. Sedimentary rocks are those rocks laid down as grains, fragments, or chemical products by water action or by the wind. The grains and chemical substances are gradually transformed into consolidated rock layers with the passage of geologic time and sandstone, shale, limestone, dolomite, and other sedimentary rock types are the result.

The conditions under which these sediments are deposited, particularly in the oceans and shallow seas, are often favorable for the existence of living organisms. When the environment is favorable for abundant plant and animal life, the remains of countless organisms may accumulate on the sea floor. It is well known that the harder portions, such as shells, may be preserved in rock as fossils. Other portions of the organic debris also may be incorporated into the sedimentary rock layers, and through processes not completely understood by science, may sometimes be converted into petroleum. This change apparently is effected by physical, biological, and chemical processes in which some combination of heat, pressure, bacterial activity, and other factors plays an important role. The resulting petroleum substances are made up of varying mixtures of compounds known as the hydrocarbons. The hydrocarbons are composed of the elements hydrogen and carbon in varying proportions. Small amounts of oxygen, nitrogen, and sulfur compounds are often present, as are traces of certain metallic elements. The rocks in which all these substances are combined to form petroleum are known as source beds of petroleum. Dark shales and limestones are considered to be the most common source beds.

Petroleum does not occur in underground rivers or lakes as is sometimes believed. The fluids contained within a rock, whether oil, gas, or water, are confined to the small pore spaces between the grains or crystals of the enclosing rock, to small solution cavities, or to fractures in the rock mass. Without porosity or fractures, which may be microscopic, a rock does not contain significant amounts of free fluid. If the rock contains openings (porosity), these openings must be interconnected to allow fluids to flow. The fluid conductivity through the interconnected openings is known as permeability. The conditions of porosity and permeability are important in several ways. Petroleum must be able to move and accumulate into commercial deposits. Without permeability a fluid cannot be made to flow from the rock openings into a well. Many wells which have located oil-bearing rocks have been abandoned because the oil could not be freed from rocks of low permeability. In order to increase the open space in the rocks immediately adjacent to a well, certain techniques have been developed. These include "shooting" with explosives, fracturing under pressure, and solution by acids.

Petroleum and natural gas are fluids which respond to various pressures within the rocks and as such they are capable of movement when there is sufficient porosity and permeability. Under certain conditions the fluids will flow laterally for considerable distances within the rock layers. This movement is termed migration. Oil and gas tend to migrate up the dip or inclination of the rock layers, following along the porous and permeable zones. In doing so they may encounter natural elements known as traps which cause them to form local accumulations. This phenomenon of migration into traps allows the hydrocarbons to form local accumulations or pools.

The numerous kinds of geologic traps may be divided into structural traps and stratigraphic traps. In either case the hydrocarbon-bearing rocks must be overlain by an impervious "roof" or "cap" rock in order to prevent the upward escape of the oil and gas. The individual fluids within any particular porous zone in the trap are commonly segregated by gravity. Water, which is the heaviest, lies at the bottom, any oil present lies above the water, and if gas is present it will occupy the highest part of the trap. Although oil and gas often occur together, either may be found alone.

In structural traps the oil or gas pools accumulate because of folding or faulting (actual displacement) of the rock layers. The simplest case of such a trap is the upfold or anticline in which oil is trapped below an impervious layer in the highest part of the up-arched rocks. Anticlinal oil accumulations have accounted for a large share of the world's oil production. Other types of structural traps may be associated with more complex folds, and with faults or actual displacement of rock layers along breaks in the earth's crust. Structural traps may sometimes be recognized by careful geologic studies at the earth's surface because the outcropping rocks may reflect the structural position of the rocks at depth.

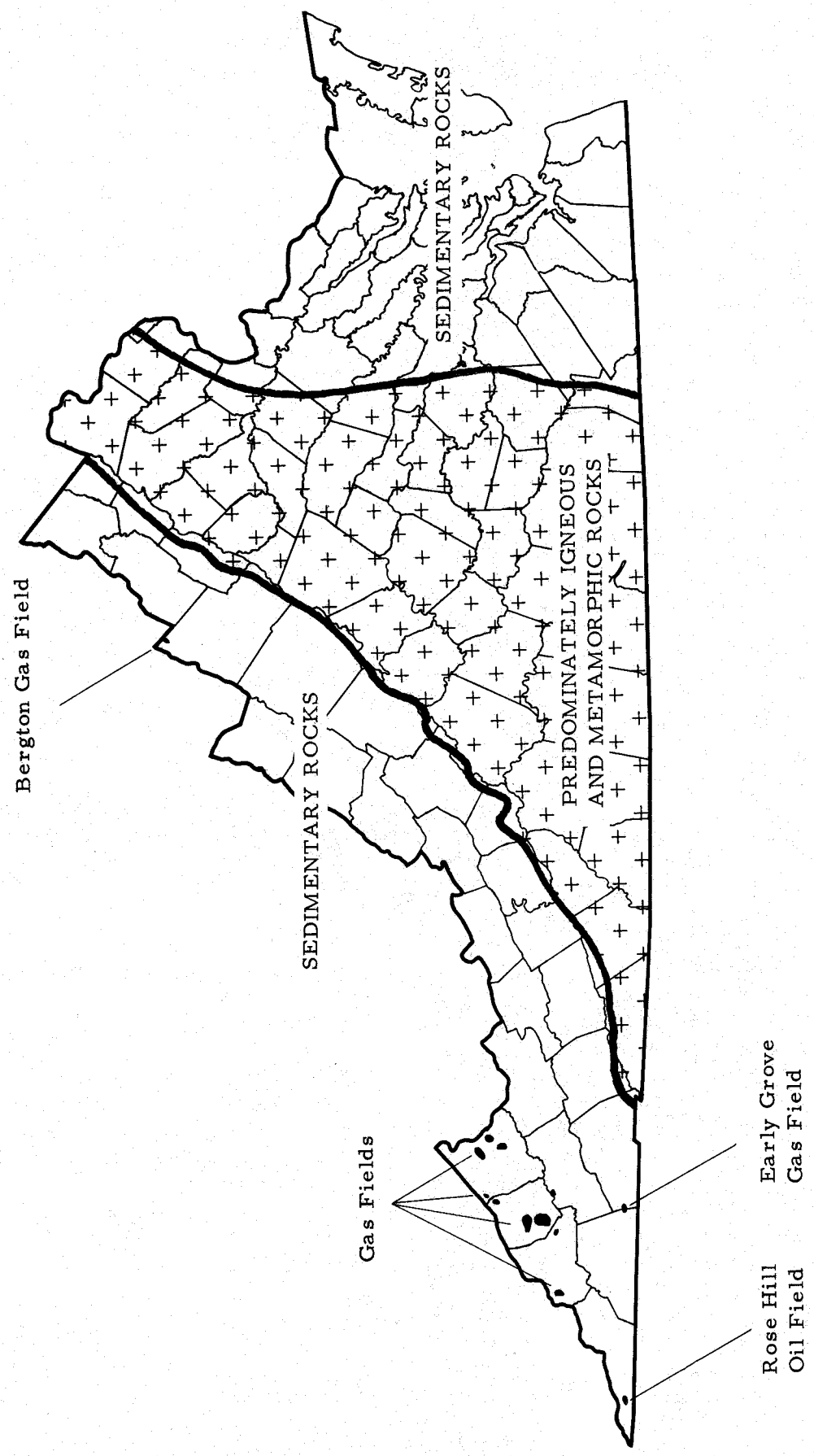

Figure 1. Outline Map of Virginia Showing Distribution of Sedimentary Rocks and Location of Oil and Gas Fields.

The accumulation of oil and gas in stratigraphic traps is controlled by a change in porosity and permeability of the enclosing rock. The hydrocarbons accumulate along the up-dip contact between permeable and nonpermeable rock materials. A simple case is that in which a porous and permeable sandstone may grade up-dip into an impermeable shale. Stratigraphic traps are usually detected by a careful geologic study of subsurface data and samples of rock cuttings and cores from wells in an area. A major portion of the world's future oil supply may be found in stratigraphic traps.

In many fields the accumulation of oil and gas results from combinations of both structural and stratigraphic traps. It should be emphasized that most of the geologic traps in the world are barren of oil or gas; the trap which contains an oil or gas pool is an exceptional case.

Surface Indications of Oil and Gas

There are certain signs that occasionally appear at the earth's surface which may be indicative of oil or gas in the rocks below. The fluid hydrocarbons in the subsurface rocks may leak to the surface if an impermeable cap rock does not form a complete seal. The fluids may also escape when a dipping porous rock layer intersects the surface, or they may leak along a zone where a fault, or a break in the rocks, intersects the surface. Any of these conditions may result in an oil seep at the surface. Although an oil seep may sometimes be an indication of an oil pool, it does not necessarily indicate a commercial accumulation. The oil may be present in minor amounts beneath the surface and possess no value. The seepage may represent oil that has migrated along a porous rock layer and the oil pool may be some distance away from the seep rather than below it. The fact that the oil is leaking or has leaked out of the ground may indicate that most of the accumulation has leaked away and that only noncommercial vestiges remain. When a seep is suspected, great care must be taken to determine the presence of oil. Other substances, especially iron scums and organic scums, are often mistaken for oil. The Division of Mineral Resources frequently receives reports and samples taken from supposed oil seeps. Most of the samples have proved to be non-oil scums. Contamination from leaking oil storage tanks sometimes causes local excitement until the true source of the oil is identified.

Decaying vegetation that has been buried to a shallow depth often generates a flammable gas known as methane, or marsh gas. Bubbles of this gas may occasionally be seen in ponds, swamps, or water wells. This condition is common in the Coastal Plain of Virginia where layers of buried vegetation occur. Marsh gas is usually a curiosity and has no economic significance.

There is no test or device which will determine the presence of underground oil or gas without actually drilling a well. There are certain geologic and geophysical techniques that are useful in determining the probable existence of a trap. However, only a well that penetrates the rocks answers the question of whether oil or gas is actually present. The drilling of a test well may be an expensive and complex process and should be undertaken only after careful geologic studies have been made. Even a scientifically-based well has only one chance in nine of finding a new oil or gas pool. Many years of exploration effort and the expenditure of large amounts of capital are often needed in order to locate the oil and gas resources of an area and to determine their true potential.

Exploration

The search for oil and gas in Virginia began in the 1890's when a well was drilled to prospect for oil and gas along Clear Creek, a few miles south of Norton, in Wise County. This well was drilled to a depth of 2153 feet and encountered a small show of gas at 626 feet. Considerable local interest was aroused but the well proved to be noncommercial and no further drilling is known to have been done in Wise County for many years. More than 300 test wells have been drilled in Virginia since the pioneer venture in Wise County. All but a few of these have been drilled in the southwestern part of the state since 1942.

The first commercial gas production in Virginia was established in June, 1931 by a well drilled on the Early Grove anticline

which trends in a northeasterly direction across the common boundary of Scott and Washington counties. The well was drilled to a total depth of 3613 feet in Scott County by the Davis Elkins interests. It had an initial potential of 1,750,000 cubic feet of gas per day. Subsequently, at least eight more wells were drilled on the anticline and a gas field was developed which extended eastward into Washington County. The gas occurs in sandy zones in the Little Valley limestone of Mississippian age. Commencing in 1938, gas from the Early Grove field was transported by a four-inch pipeline for use in the city of Bristol. However, production has declined during the past few years and no recent drilling has been done.

Within the past decade natural gas reserves have been developed in the coal-producing area of southwestern Virginia in Buchanan, Dickenson, Russell, and Wise counties. The gas occurs in fractured Devonian shales and in sandstones and limestones of Mississippian age. The potential production of wells completed in the limestone is often increased by acidizing the well, and that of the sand and shale wells by "shooting" with explosives. Gas from Buchanan County is delivered to the pipeline system of the Hope Natural Gas Company and that from Dickenson County to the Kentucky West Virginia Gas Company. However, much of the area has no pipeline facilities available and, therefore, the true productive potential of many of the gas wells has not been accurately determined.

In Buchanan County a total of 107 test wells are known to have been drilled. The depths range from 2147 to 8013 feet. The total production of natural gas in the county in 1957 was 1,042,658,000 cubic feet according to figures included in the Annual Report of the Virginia Department of Labor and Industry for 1957.

Natural gas was first discovered in Buchanan County in 1948 by the United Producing Company, of Charleston, West Virginia, near Keen Mountain, six miles east of Grundy. The well, W. M. Ritter Lumber Company No. 1-V-1461, was drilled to a total depth of 2301 feet and had an initial potential of 17,196,000 cubic feet of gas per day from the Princeton sandstone of Mississippian age. Subsequently, the United Producing Company drilled more than 20 wells in the Keen Mountain area to develop this gas field. Another gas field, which produces from the Berea sandstone of Mississippian age at depths from 4600 to 5300 feet, has been developed two miles northeast of Dwight in the eastern part of the county by the same company. United Producing Company has also completed gas wells in other areas in east-central Buchanan County. The company has been active in the area since 1948 and has drilled a total of 76 test wells. During 1958 the United Producing Company completed three gas wells and one dry hole having an aggregate footage of 18,487 feet.

The Clinchfield Coal Company of Dante, Virginia, drilled seven wells in western Buchanan County between 1950 and 1956. That company is currently drilling a well six miles north of Vicey. The United Fuel Gas Company, Charleston, West Virginia, has drilled ten wells in Buchanan County since 1948, nine of which are in the northern and eastern parts of the county, and one in the south-central part. Gas was found in several of the wells located immediately south of the Virginia-Kentucky boundary. In this area the United Fuel Gas Company is currently drilling a well four miles north of Hurley. A series of ten test wells was drilled by the Pipe Line Construction and Drilling Company, Pikeville, Kentucky, in central Buchanan County between 1948 and 1953. At least seven of these wells were reported to have been completed as gas wells. Three wells were drilled a few miles east of Grundy by the Slate Creek Development Program of Cincinnati, Ohio, between 1950 and 1952. Two of these wells were abandoned as dry holes and the third was reported as a small gas well.

In Dickenson County a total of 77 wells have been drilled by the Clinchfield Coal Company. The depths range from 3269 to 7245 feet. The total natural gas production for 1957 was reported as 1,548,239,000 cubic feet by the Virginia Department of Labor and Industry, making Dickenson County the state's leading gas-producing county during the year. The first discovery of natural gas in this county was made by the Clinchfield Coal Company at the No. 101 H. P. Phillips well, near the town of Nora.

The well was completed in April, 1949 at a total depth of 4551 feet with an initial potential of 1,632,000 cubic feet of gas per day from the Greenbrier limestone of Mississippian age. The Clinchfield Coal Company has subsequently developed gas production in the Nora and Open Fork areas, and also has drilled three gas wells in the Barts Lick area. It is currently drilling three wells, one in the Barts Lick area; one located one mile southeast of Clinchco; and one in the Open Fork field. During 1958, this company completed seven new gas wells in Dickenson County having an aggregate footage of 39,135 feet.

The 1957 natural gas production in Wise County is reported at 4,670,000 cubic feet. Twenty-five wells have been drilled in Wise County since the 1890's ranging in known depth from 1407 to 6277 feet. Shows of gas were reported in many of the earlier wells. Gas was encountered in three wells drilled by the Southwestern Oil and Gas Company a few miles southwest of Coeburn from 1939 to 1941. Several shows of gas were reported in a well drilled to 3670 feet by the Virginia Oil and Gas Company in 1932-33 at a location one-quarter mile south of Lipps. The Clinchfield Coal Company has drilled 18 wells in the county since 1953. The first of these was the No. 143, two miles south of Flat Gap, which was completed as a gas well at a total depth of 5349 feet. Subsequent drilling has been concentrated in the Stonega area in western Wise County and near Toms Creek in the eastern part. The company is currently drilling a well one mile south of Lipps. During 1958, the Clinchfield Coal Company completed two gas wells in the county having a combined footage of 10,306 feet.

Less exploratory work has been carried on in Russell County than in the other southwestern Virginia counties. A total of seven wells, ranging in total depth from 4856 to 7029 feet, have been drilled. The first test well in the county was drilled in 1932 by the Penn-Ohio Gas Company of Pittsburgh, Pennsylvania, at a location four miles north of Cleveland. The well was abandoned at a total depth of 6006 feet, reportedly in Devonian shale. Since that time the Clinchfield Coal Company has been the only company to drill in the county. From 1955 to 1957, this company drilled six wells that are located four miles east of Dante. Three of the tests were completed as gas wells and three were abandoned as dry holes. The total yield of gas during 1957 in Russell County, reported by the Virginia State Department of Labor and Industry was 720,000 cubic feet, all of which was utilized in drilling operations.

Natural gas has also been found in extreme northern Rockingham County near the town of Bergton. The gas occurs at depths of approximately 2600 to 4000 feet in the Oriskany sandstone along the Bergton-Crab Run anticline. The field is located a few miles south of a pipeline of the Columbia Gas Company, however, no local gathering system has been established. At least four wells were drilled during the 1930's, one of which, drilled by the Great Eastern States Gas Company, attracted considerable attention. The well was drilled on the C. L. Souder property to a depth of 2986 feet and was completed in 1940. It encountered a flow of gas reported at from 60,000 to 100,000 cubic feet per day, in the top of the Oriskany sandstone. Subsequently, the well was acquired by the United Fuel Gas Company and deepened in 1951 to 2994 feet. The well was completed at this depth as a gas well with an initial potential of 1,043,000 cubic feet per day. Since that time 11 more wells have been drilled, of which four have been gas wells and seven dry holes. The United Fuel Gas Company completed two wells in 1952, one a dry hole, the other a gas well with a reported potential of 286,000 cubic feet per day. During the same year, Snee and Eberley, of Uniontown, Pennsylvania, completed a well less than one-half mile north of the Souder well for an initial potential of 9,700,000 cubic feet per day from the Oriskany at a total depth of 3077 feet. The United Fuel Gas Company drilled three dry holes in 1955, and in 1956 the company completed two gas wells for reported initial potentials of 94,000 and 1,078,000 cubic feet per day. In 1957, Ralph E. Davis of Houston, Texas, drilled three dry holes in the vicinity of Bergton. No drilling was done in Rockingham County in 1958.

Oil is produced in Virginia at the Rose Hill oil field in western Lee County. The field is located on the Powell Valley

anticline which is a dominant geologic feature in the county. The underlying geologic pattern of the area is made obscure by the presence of the Cumberland overthrust block that has been shoved several miles to the northwest across the Rose Hill district. The block rests on the Pine Mountain thrust fault. Most of the wells are drilled in small areas where the overlying Cumberland overthrust block has been eroded away so that the rocks that underlie the thrust fault are visible.

Wells in search of petroleum were drilled in the Rose Hill area as early as 1910. During the 1920's several wells were drilled which encountered appreciable showings of oil. One of these wells is reported to have yielded a few barrels of oil; however, commercial production was not established until May, 1942, when a well, now known as the B. C. Fugate No. 1, was drilled by R. Y. Walker of Baton Rouge, Louisiana. The well penetrated oil-bearing rocks at 1110 feet. During the first day of testing, the well yielded 90 barrels of oil. However, after testing, and after being shut in for almost a year, the well settled to a rate of approximately eight barrels per day. After this discovery at least 60 additional wells were drilled in the area, over one-half of which were reported to have been small producers.

Most of the oil is found in the Trenton limestone of Ordovician age which is penetrated at depths of 800 to 2000 feet. The oil has a gravity of 44° A. P. I., a paraffin base, and little associated gas. The wells are reported to have a productive life of from three months to two years. Production has declined in recent years and no new wells have been drilled during the past few years. A total production of 4517 barrels was reported in 1957. A comprehensive study of the Rose Hill field, from which much of the above summary was taken, has been presented by R. I. Miller and J. O. Fuller in Bulletin 71 of the Division of Mineral Resources, entitled "Geology and Oil Resources of the Rose Hill District . . . ."

Several unsuccessful wells have been drilled in search of oil or gas in counties other than those discussed. The deepest of these, which is also the deepest well in Virginia, was drilled in 1949 by The California Company in Montgomery County four miles southwest of Blacksburg. This well, the Kipps Anthracite Coal Co. No. 1, was abandoned as a dry hole at a total depth of 9340 feet after encountering only a show of gas. The California Company drilled a well in Giles County in 1948 which was also abandoned as a dry hole at a depth of 1443 feet. In Tazewell County, the United Producing Company drilled a dry hole in Burkes Garden to a depth of 5632 feet which was abandoned in 1950. In Wythe County, I. Groskins and others drilled a well two miles east of Wytheville which was abandoned. In Mathews County, the Elkins Oil and Gas Company drilled a well at the town of Mathews which was abandoned as a dry hole at a depth of 2325 feet.

Services of the Division of Mineral Resources

The Division of Mineral Resources has records on many of the wells drilled for oil and gas in Virginia, especially those drilled since 1948. The Division maintains a well-sample library of rock cuttings that are recovered during the drilling of wells. Samples from 135 oil and gas wells are on file and samples are added from each new well. More than 50,000 individual well samples representing 390,000 feet of rock strata are available. These samples are of invaluable assistance in gaining an evaluation of the rock strata penetrated by the drill and are available for study at the Division offices by professional geologists.

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NEW QUARRIES

The Chantilly Crushed Stone Company recently has opened a quarry in diabase just north of U. S. Highway 50 near Arcola, Loudoun County. Road aggregate and concrete aggregate is produced. The company will supply crushed stone for use in the construction of the Chantilly Airport, the new airport that will serve the metropolitan area of Washington, D. C.

The Louisa Stone Company recently opened a quarry near Louisa, Louisa County. Granite is quarried for use as road aggregate and concrete aggregate.

Buffalo Mines, Inc. will begin production of aplite at a new quarry and plant near Piney River, Nelson County, about May 1, 1959. Most of the production will be used as roofing granules. A by-product will be sold to the glass industry.